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DESCRIPTION

APPARATUS AND METHOD FOR EXPANDING CHANNELS IN CDMA SYSTEM

1. Technical Field

The present invention relates to channels of code division multiple access systems and, more particularly, to an apparatus and method for increasing availabe channels in a code division multiple access (CDMA) transmit modulator.

2. Background Art

Fig. 1 shows a block diagram of a code division multiple access (CDMA) transmit modulator of the conventional art. The transmit modulator comprises a channel encoder 110, which includs a convolution encoder 111, a symbol repeater 112 and an interleaver 113, for convolutionally encoding with repetition and interleaving the input data from a mobile station; a channel modulator 120, which includs a Walsh code combiner 121 and a Walsh code generator 122, for combining the output of channel encoder 100 with a Walsh code such that this channel is distinguishable from the other traffic channels in the allocated frequency assignment; a pseudo noise (PN) code combining unit 130, including first and second PN code combiners 131 and 132, for combining the output of Walsh code combiner 121 and both of in-phase (I) and quadrature (Q) channel PN sequences, PN_I and PN_Q, which are generated and determined by a predetermined PN offset value such that multiple cell-sites or sectors using the same frequency assignment are distinguished from one another; a lowpass filter 140, including first and second digital finite impulse response (FIR) filters 141 and 142, for filtering out

high frequency components of the outputs of the first and second PN code combiners 131 and 132 and flattens them in the frequency assignment; an analog signal modulator 150, including first and second mixers 151 and 152, for multiplying the D/A-converted signals of the first and second FIR filters 141 and 142 with sine and cosine functions and producing the modulated analog signals; an analog signal summer 160 for summing the outputs of analog signal modulator 150; an intermediate frequency (IF) modulator 170 for modulating the signal of analog signal summer 160 by using the quadrature phase shift key (QPSK) modulation; a frequency up-converter 180 for up-converting the IF signal into a radio frequency (RF) signal; and an RF transmitter 190 for amplifying and radiating the RF signal through an antenna system.

The operation of the transmit modulator of the conventional art, shown in FIG. 1, is described below in detail.

The channel input data from a vocoder is convolutionally encoded for error correction by convolutional encoder 111. The encoding rate of convolutional encoder 111 is twice the input data rate. For example, for the input data symbols whose rate is 9,600 bits per seoncd (bps), convolutional encoder 111 outputs data symbols whose rate is 19,200 bps. The encoded data is then provided as input to symbol repeater 112. Depending on the input data rate, the symbols are repeated by symbol repeater 112 in order that the rate of the resulting output of symbol repeater 112 becomes 19,200 bps. That is, symbols are repeated for the input data of low rates. For example, if the input data rate is 9,600 bps, the symbols are repeated twice, if the input data rate is 4,800 bps, they are repeated four times, and so on. The repeated symbols are inputted to interleaver 113. Interleaving is done by interleaver 113 with reference to a predetermined sequence to spread possible burst errors into random errors.

Walsh code generator 122 generates a Walsh code that is used to have this channel to be distinguished from other traffic channels. It should be noted that the transmit modulator with capacity of M channels has M channel modulators, each with its own Walsh code. The Walsh codes used in the channel modulators are orthogonal to each other. For simplicity, only one traffic channel is depicted in the transmit modulator of FIG. 1.

The interleaved symbol output and the Walsh sequence are exclusive-OR'ed by Walsh code combiner 121. The chip rate of Walsh code becomes the CDMA spreading speed. The spread data stream is provided as input to a QPSK modulater comprising PN code combining unit 130, lowpass filter 140, analog signal modulator 150, and analog signal summer 160. The data stream from channel modulator 120 is inputted to each of PN code combiners 131 and 132 that multiply the data stream by in-phase and quadrature channel PN sequences, respectively. The two resulting data stream are provided as input to lowpass filter 140 for bandwidth reduction and are then modulated to analog signals through two mixers 151 and 152. The outputs of the mixers 151 and 152 are added into an analog signal by analog signal summer 160.

The output signal of analog signal summer 160 is modulated into an IF signal by IF signal modulator 170. Frequency up-converter 180 converts the IF signal to an RF signal and then the RF signal is amplified, bandpass filter, and radiated through an antenna system by RF transmitter 190.

When 64 Walsh codes are used for channelization, 64 channels are totally available in the transmit modulator of FIG. 1, because only one traffic channel is available for each channel modulator. Except the pilot, the sync, and the paging channels, 61 channels can be used for traffic channels. Therefore, about 30 channels can be at most be maintained in

the transmit modulator to support the good-quality communication service (It is known in the art that the number of channels of good-quality service is about 30 even though there are 61 available traffic channels). Hence, as the number of users increases, the channel resource that should be allocated to each user decreases. As a result, if the existing voice channels are used for data communication service, it is impossible to obtain more data channels, so that the data communication cost increases because users pay the same cost as that of the existing voice channels. It is reason why it is difficult to provide data communication service at a lower cost.

3. Disclosure of Invention

It is a primary object of the present invention to provide a method and apparatus for increasing the number of channels in a code division multiple access (CDMA) system by dividing a traffic channel into a plurality of subchannels of low data rate.

It is another object of the present invention to provide a method and apparatus for enabling reliable and long-distance communication with low power in a CDMA system by obtaining progcessing gain on the subchannels of low data rate in the demodulation process.

In a code division multiple access (CDMA) transmit modulator comprising a channel encoder for convolutionally encoding input signal from a vocoder with symbol repetition and interleaving the encoded signal; a channel modulator for combining the output signal from the channel encoder and an orthogonal code corresponding to a traffic channel; a pair of pseudo noise (PN) combiners, each for combining the modulated signal and a respective one of a pair of predetermined-offset PN signals; a pair of lowpass filters, each for filtering a respective output signal of the pair of

PN combiners and flattening the power level of the resulting signal; a pair of digital-to-analog converters, each for converting a respective output signal of the pair of lowpass filters to analog signal; and an analog signal summer for summing the analog signals of the pair of digital-to-analog converters, an channel increasing apparatus according to the present invention comprises a plurality of subchannel encoders substituted for said channel encoder, each for convolutionally encoding with symbol repetition and interleaving input data from a respective one of a plurality of subchannels, the data rate of each of ~~s~~the plurality of subchannels being lower than the encodable date rate of the traffic channel by said channel encoder; a plurality of subchannel modulators, each for combining an output signal from a respective one of said plurality of subchannel encoders and a respective orthogonal code signal distinguishing one from another subchannel, all subchannels being accommodated in a single traffic channel; and a subchannel summer for summing output signals of said plurality of the subchannel modulators and providing the summed signal to said channel modulator..

The apparatus according to the present invention provides the following advantages.

First, because each of traffic channels can be divided into a plurality of subchannels of low data rate utilizing multiple modulation, the apparatus makes it possible to efficiently use the channel resource. Therefore, the apparatus enables to provide more data channels of low data rate and to reserve more voice channels for cellular phones as well.

Second, the increase of processing gain in the correlation detection by using multiple modulation of subchannels of low data rate enables data of low rate to be transmitted farther and more reliably with less power than in the transmit

modulator of the conventional art.

Third, in environments where data transmission using CDMA voice channels is nearly impossible, the apparatus enables data transmission of low rate and thus be utilized in very long distance communication and/or sea rescue communication systems.

4. Brief Description of Drawings

The accompanying drawings, which are included to provide a further understanding of the invention, illustrate the preferred embodiment of this invention, and together with the description, serve to explain the principles of the present invention.

In the drawings:

FIG. 1 is a block diagram of a CDMA transmit modulator;

FIG. 2 is a block diagram of a CDMA transmit modulator equipped with the apparatus according to an embodiment of the present invention; and

FIG. 3 is a block diagram of a subchannel summer shown in FIG. 2.

5. Modes for Carrying out the Invention

Hereinafter, a preferred embodiment of the present invention will be described in detail referring to the accompanying drawings.

FIG. 2 shows a block diagram of a transmit modulator including the apparatus according to an embodiment of the present invention. In the transmit modulator, the following constituting components: channel modulator 120, PN code combining unit 130, lowpass filter 140, analog signal modulator 150, analog signal summer 160, IF signal modulator 170, frequency up-converter 180, and RF transmitter 190 are all the same as those of the transmit modulator of FIG. 1. Hence, their numbers on FIG. 2 is the same as those of FIG. 1 and thus the description of their operations is omitted

here.

As shown in FIG. 2, the apparatus 200 according to an embodiment of the present invention comprises a plurality of subchannel encoders 210 (210-1, 210-2, …, 210-N, where N is the number of subchannels), the function of each subchannel encoder being the same as that of channel encoder 110 of FIG. 1, a plurality of subchannel modulators 220 (220-1, 220-2, …, 220-N), and a subchannel summer 230.

The input data on each subchannel is convolutionally encoded with repetition and then interleaved by a respective one of the plurality of subchannel encoders. It should be noted that each input data rate is lower than the encodable input data rate by channel encoder 110 of FIG. 1 (hereinafter, 19.2 kbps) divided by the number of subchannels. That is, the input data rate on each subchannel is lower than 19.2/N kbps. Each subchannel modulator combines data that is provided at a rate lower than 19.2/N kbps on the corresponding subchannel encoder and a respective orthogonal code of 19.2 kbps rate that is selected from an orthogonal code set, f1 through fn (code fl and code fm are orthogonal each other if l is not equal to m). Hereinafter, such orthogonal codes are referred to as subchannel orthogonal seuquences. Subchannel summer 230 sums the outputs of the plurality of subchannel modulators 220, each inputted at 19.2 kbps rate, and provides the summed output data to channel modulator 120.

Subchannel summer 230, as shown in FIG. 3, comprises a plurality of subchannel memories 231 (231-1, 231-2, …, 231-N), each for storing the subchannel data from the corresponding subchannel modulator, and a data processor 232 for processing the data stored in the plurality of subchannel memories 231. It should be noted that subchannel summer 230 is capable of reducing the energy of the output of subchannel summer 230. To be specific, At a rate of 19.2 kbps, the output of each

subchannel modulator is inputted to subchannel summer 230. Summing each input data of 19.2 kbps increases the energy of the output of subchannel summer 230, which causes noise or cross-talk over other traffic channels. Therefore, it is required to reduce the energy of each of the subchannel data.

Hereinafter, the operations of multiple modulation in the apparatus according to an embodiment of the present invention will be described in detail.

Input data on each subchannel is convolutionally encoded, with symbol repetition, and interleaved by a respective one of the plurality of subchannel encoders and is then provided as input to a respective one of the plurality of subchannel modulators. It should be understood that it is required that the data rate of each subchannel is lower than 19.2/N kbps, where N is the number of subchannels. For example, if subchannel orthogonal sequence used for each subchannel modulator is 64-bit long and is generated at a rate of 19.2 kbps, the data rate of each subchannel should be lower than 300 bps in order that data chip of 1 bit is multiplied by 64 bit-long subchannel orthogonal sequence of 19.2 kbps (64/19.2 kbps = 1/300). This requirement of the data rate of each subchannel is satisfied when the number of subchannels is smaller than 64.

Each subchannel modulator multiplies the subchannel encoded data by a respective one of subchannel orthogonal sequences, f1, f2, …, fn, and provides the modulated subchannel data to subchannel summer 230. It should be noted that the bit rate of each subchannel orthogonal sequence is lower than the bit rate of Walsh codes, each being used in channel modulator for distinguishing traffic channels in the frequency assignment (FA). For example, each subchannel orthogonal sequence of 19.2 kbps is multiplied with respective low speed input data to distinguish a subchannel

from others. All subchannels with subchannel orthogonal sequence multiplied are applied to subchannel summer 230. In this way, a plurality of subchannels of low data rate can be obtained within each traffic channel.

As shown in FIG. 3, the output of each subchannel modulator is stored in the corresponding subchannel memory 231 and is then provided as input to the subchannel data processor 232 in which the stored data are processed so as to reduce its energy level. In this data process, value 0 is considered as -1. The output of the subchannel summer 230 requires more representation levels than two levels because the output should represent the sum of the outputs of the plurality of subchannels. For example, if the number of subchannels is 16, the output of the subchannel summer 230 should be represented with 32 levels from -16 to +16. Hence, 5 bits are required to represent an output level of channel summer 230.

Channel modulator 120 combines several bits belonging to single output level of subchannel summer 230 and a Walsh code defining a traffic channel. Because the data rate of each subchannel is M (M is an integer) times lower than that of the traffic channel to which the subchannels belong, the output of subchannel summer 320 is not varied over a period of the Walsh sequence. Therefore, the plurality of subchannels can be formed within each traffic channel. In addition, a received signal gain is increased since data signal, whose energy is detected through a correlation process with a Walsh code, of a subchannel undergoes a correlation process again with a subchannel orthogonal sequence.

The output of channel modulator 120 in which each subchannel data is modulated is combined with each of a pair of PN codes by PN code combining unit 130. The pair of PN codes are generated with preset-offset phase such that multiple

cell-sites or sectors using the same frequency assignment are distinguished from one another. This PN code spreads several bits indicative of mixed value of all subchannel data.

Then, the outputs of PN code combining unit 130 are provided as input to lowpass filter 140 that filters and flattens the outputs using a pair of digital FIR filters such that the outputs of lowpass filter 140 has flat power level in the frequency assignment. It should be noted that the plurality of subchannels belonging to a traffic channel are processed simultaneously by the pair of digital FIR filters.

The digital signals of lowpass filter 140 are modulated into analog signals by analog signal modulator 150 that includes a pair of digital-to-analog converters and a pair of mixers, and are then provided to analog signal summer 160. The analog signals are summed into an analog signal by analog signal summer 160 and the resulting analog signal is inputted to IF signal modulator 170. If it happens that the energy of the output of analog signal summer 150 is high due to the summation of signals of all traffic channels, the energy of the output signal is reduced to an appropriate energy level by analog signal summer 150.

Receiving the output signal from analog signal summer 150, IF signal modulator 170 produces a modulated signal using QPSK modulation. In case of QPSK modulation, in-phase and quadrature phase PN sequences are used in PN code combining unit 130, and sine and cosine functions are used in the pair of mixers of analog signal modulator 150.

The IF signal is up-converted into an RF signal by frequency up-converter 180. The RF signal is amplified by an RF amplifier (not shown), and is then bandpass filtered and radiated through an antenna system (not shown).

The foregoing is provided only for the purpose of illustration and explanation of the preferred embodiments of

the present invention, so changes, variations and modifications may be made without departing from the spirit and scope of the invention.